Captain John Tye pictured by Concorde

This is a historical work
based on public sources
and some of the author's own experiences
as an airline aircraft technician

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Concorde

On the Wings Of Time

"Time waits for no one" "Time is of the essence" “Better three hours too soon than a minute too late.” Such was the driving force behind the concept and development of the Concorde SST. The origins of the Concorde project date to the early 1950s, when Arnold Hall, director of the Royal Aircraft Establishment (RAE), asked Morien Morgan to form a committee to study the supersonic transport (SST) concept. The group met for the first time in February 1954 and delivered their first report in April 1955.

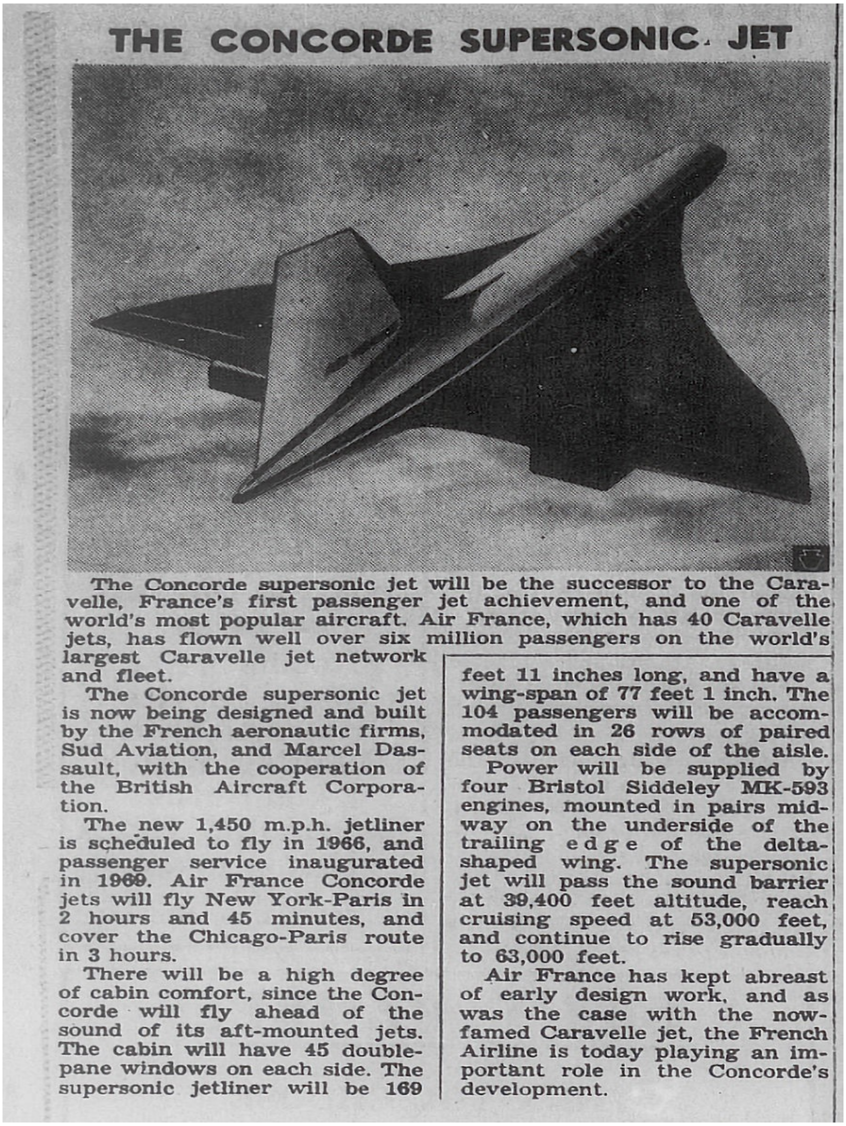
Arnold Hall

Sir Morien Morgan

The Aérospatiale/BAC Concorde is a retired Franco-British supersonic airliner jointly developed and manufactured by Sud Aviation (later Aérospatiale) and the British Aircraft Corporation (BAC). Studies started in 1954, and France and the UK signed a treaty establishing the development project on 29 November 1962, as the programme cost was estimated at £70 million (£1.39 billion in 2021). Construction of the six prototypes began in February 1965, and the first flight took off from Toulouse on 2 March 1969. The market was predicted for 350 aircraft, and the manufacturers received up to 100 option orders from many major airlines. On 9 October 1975, it received its French Certificate of Airworthiness, and from the UK CAA on 5 December.

Concorde is a tailless aircraft design with a narrow fuselage permitting a 4-abreast seating for 92 to 128 passengers, an ogival delta wing and a droop nose for landing visibility. It is powered by four Rolls-Royce/Snecma Olympus 593 turbojets with variable engine intake ramps, and reheat (afterburner) for take-off and acceleration to supersonic speed.

Constructed out of aluminium, it was the first airliner to have analogue fly-by-wire flight controls. The airliner could maintain a supercruise up to Mach 2.04 (2,170 km/h; 1,170 kn) at an altitude of 60,000 ft (18.3 km). Concorde entered service on 21 January 1976 with Air France from Paris-Roissy and British Airways from London Heathrow. Transatlantic flights were the main market, to Washington Dulles from 24 May, and to New York JFK from 17 October 1977. Air France and British Airways remained the sole customers with seven airframes each, for a total production of twenty. Supersonic flight more than halved travel times, but sonic booms over the ground limited it to transoceanic flights only.



THE CONCORDE SUPERSONIC JET

The Concorde supersonic jet will be the successor to the Caravelle, France's first passenger jet achievement, and one of the world's most popular aircraft. Air France, which has 40 Caravelle jets, has flown well over six million passengers on the world's largest Caravelle jet network and fleet.

The Concorde supersonic jet is now being designed and built by the French aeronautic firms, Sud Aviation, and Marcel Dassault, with the cooperation of the British Aircraft Corporation.

The new 1,450 m.p.h. jetliner is scheduled to fly in 1966, and passenger service inaugurated in 1969. Air France Concorde jets will fly New York-Paris in 2 hours and 45 minutes, and cover the Chicago-Paris route in 3 hours.

There will be a high degree of cabin comfort, since the Concorde will fly ahead of the sound of its aft-mounted jets. The cabin will have 45 double-pane windows on each side. The supersonic jetliner will be 169 feet 11 inches long, and have a wing-span of 77 feet 1 inch. The 104 passengers will be accommodated in 26 rows of paired seats on each side of the aisle.

Power will be supplied by four Bristol Siddeley MK-593 engines, mounted in pairs midway on the underside of the trailing edge of the delta-shaped wing. The supersonic jet will pass the sound barrier at 39,400 feet altitude, reach cruising speed at 53,000 feet, and continue to rise gradually to 63,000 feet.

Air France has kept abreast of early design work, and as was the case with the now-famed Caravelle jet, the French Airline is today playing an important role in the Concorde's development.

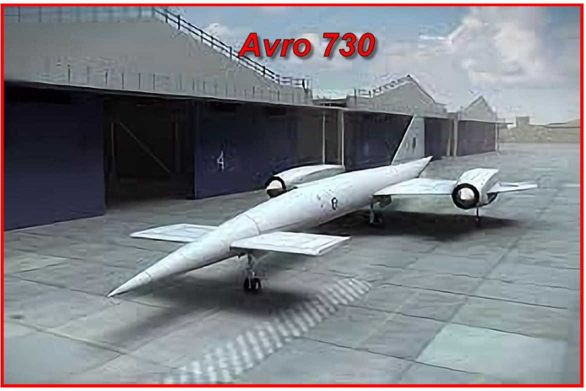
Jackson Advocate Nov 30, 1963

Its only competitor was the Tupolev Tu-144, carrying passengers from November 1977 until a May 1978 crash, while a potential competitor, the Boeing 2707, was cancelled in 1971 before any prototypes were built. On 25 July 2000, Air France Flight 4590 crashed shortly after take-off with all 109 occupants and four on ground killed, the only fatal incident involving Concorde, and commercial service was suspended until November 2001. Concorde aircraft were retired in 2003 after 27 years of commercial operations. Most aircraft are on display in Europe and America.

Development - Early studies

At the time it was known that the drag at supersonic speeds was strongly related to the span of the wing. This led to the use of short-span, thin trapezoidal wings such as those seen on the control surfaces of many missiles, or in aircraft such as the Lockheed F-104 Starfighter interceptor or the planned Avro 730 strategic bomber that the team studied. The team outlined a baseline configuration that resembled an enlarged Avro 730.

This same short span produced very little lift at low speed, which resulted in extremely long take-off runs and high landing speeds. In an SST design, this would have required enormous engine power to lift off from existing runways, and to provide the fuel needed, "some horribly large aeroplanes" resulted. This concept was not developed.



Slender Deltas

Soon after, Johanna Weber and Dietrich Küchemann at the RAE published a series of reports on a new wing planform, known in the UK as the "slender delta" concept. The team, including Eric Maskell whose report "Flow Separation in Three Dimensions" contributed to an understanding of the physical nature of separated flow, worked with the fact that delta wings can produce strong vortices on their upper surfaces at high angles of attack. The vortex will lower the air pressure and cause lift to be greatly increased. This effect had been noticed earlier, notably by Chuck Yeager in the Convair XF-92, but its qualities had not been fully appreciated. Weber suggested that this was no mere curiosity, and the effect could be used deliberately to improve low speed performance.

Johanna Weber was a mathematician who began her career in Germany but continued after World War II in England. She worked on aerodynamics and played a large part in designing the wings of Concorde and of the Airbus.

Küchemann's and Weber's papers changed the entire nature of supersonic design almost overnight. Although the delta had already been used on aircraft prior to this point, these designs used planforms that were not much different from a swept wing of the same span.

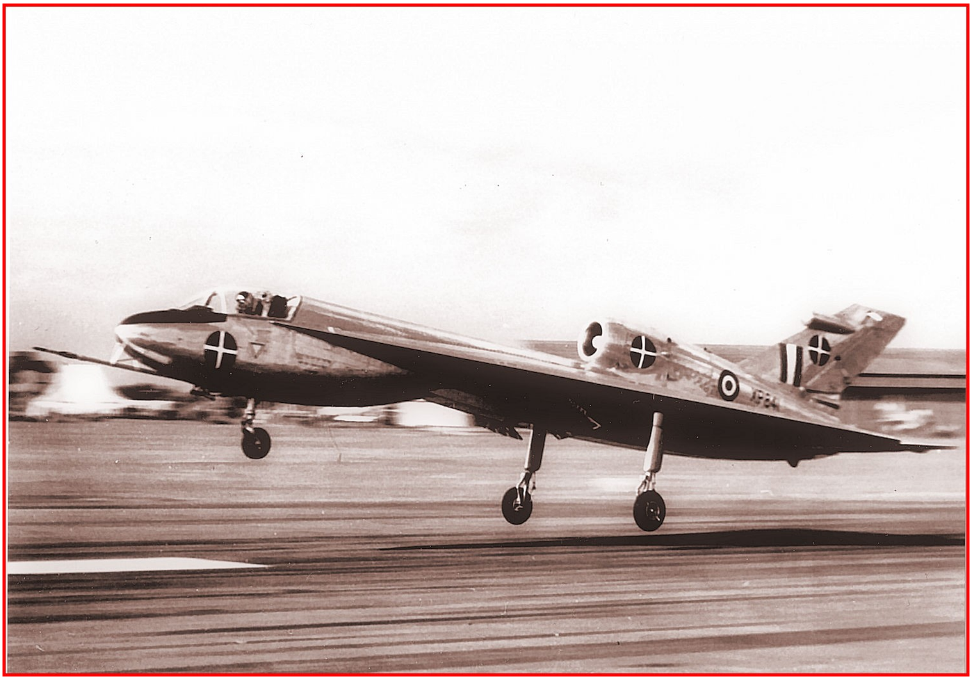
Weber noted that the lift from the vortex was increased by the length of the wing it had to operate over, which suggested that the effect would be maximised by extending the wing along the fuselage as far as possible. Such a layout would still have good supersonic performance inherent to the short span, while also offering reasonable take-off and landing speeds using vortex generation.

The only downside to such a design is that the aircraft would have to take off and land very "nose high" to generate the required vortex lift, which led to questions about the low speed handling qualities of such a design. It would also need to have long landing gear to produce the required angle of attack while still on the runway.

Dietrich Küchemann presented the idea at a meeting where Morgan was also present. Test pilot Eric Brown recalls Morgan's reaction to the presentation, saying that he immediately seized on it as the solution to the SST problem. Brown considers this moment as being the true birth of the Concorde project.

Supersonic Transport Aircraft Committee

On 1 October 1956 the Ministry of Supply asked Morgan to form a new study group, the Supersonic Transport Aircraft Committee (STAC) (sometimes referred to as the Supersonic Transport Advisory Committee), with the explicit goal of developing a practical SST design and finding industry partners to build it. At the first meeting, on 5 November 1956, the decision was made to fund the development of a test bed aircraft to examine the low-speed performance of the slender delta, a contract that eventually produced the Handley Page HP.115. This aircraft would ultimately demonstrate safe control at speeds as low as 69 mph (111 km/h), about that of the F-104 Starfighter.



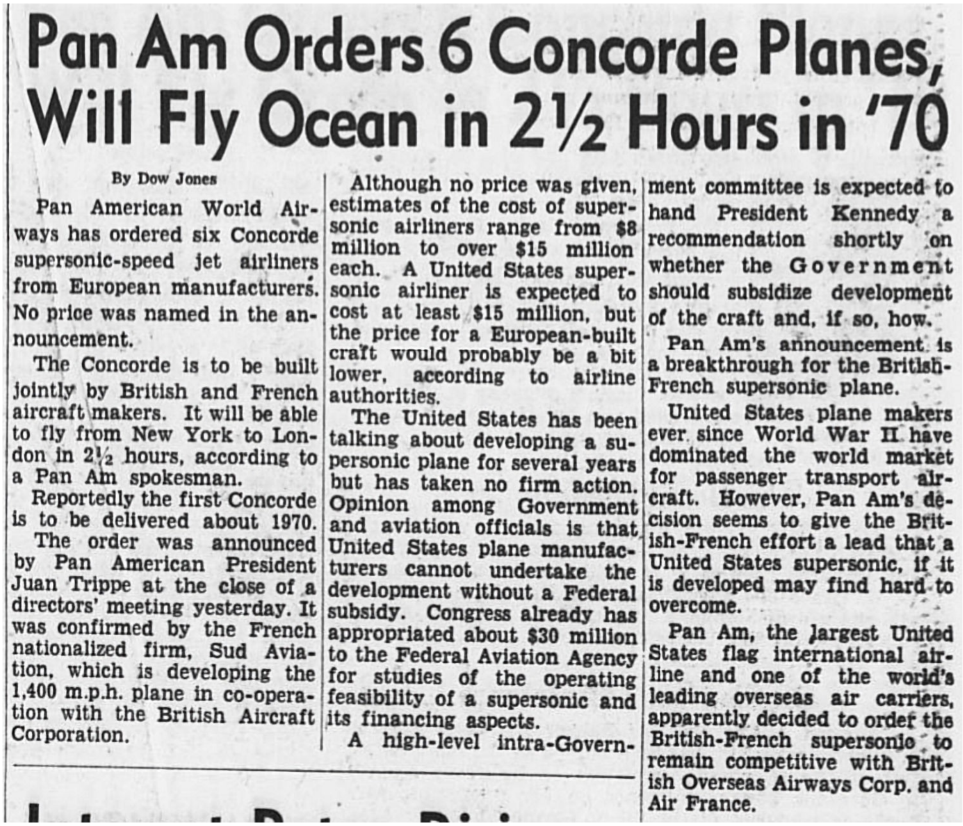
Handley Page HP 115 test aircraft

STAC stated that an SST would have economic performance similar to existing subsonic types. A significant problem is that lift is not generated the same way at supersonic and subsonic speeds, with the lift-to-drag ratio for supersonic designs being about half that of subsonic designs.

This means the aircraft would have to use more power than a subsonic design of the same size. But although they would burn more fuel in cruise, they would be able to fly more sorties in a given period of time, so fewer aircraft would be needed to service a particular route. This would remain economically advantageous as long as fuel represented a small percentage of operational costs, as it did at the time.

STAC suggested that two designs naturally fell out of their work, a transatlantic model flying at about Mach 2, and a shorter-range version flying at Mach 1.2 perhaps. Morien Morgan suggested that a 150-passenger transatlantic SST would cost about £75 to £90 million to develop, and be in service in 1970. The smaller 100 passenger short-range version would cost perhaps £50 to £80 million, and be ready for service in 1968. To meet this schedule, development would need to begin in 1960, with production contracts let in 1962. Morgan strongly suggested that the US was already involved in a similar project, and that if the UK failed to respond it would be locked out of an airliner market that he believed would be dominated by SST aircraft.

In 1959, a study contract was awarded to Hawker Siddeley and Bristol for preliminary designs based on the slender delta concept, which developed as the HSA.1000 and Bristol 198. Armstrong Whitworth also responded with an internal design, the M-Wing, for the lower-speed shorter-range category. Even at this early time, both the STAC group and the government were looking for partners to develop the designs. In September 1959, Hawker approached Lockheed, and after the creation of British Aircraft Corporation in 1960, the former Bristol team immediately started talks with Boeing, General Dynamics, Douglas Aircraft, and Sud Aviation.



Pan Am Orders 6 Concorde Planes, Will Fly Ocean in 2½ Hours in '70

By Dow Jones

Pan American World Airways has ordered six Concorde supersonic-speed jet airliners from European manufacturers. No price was named in the announcement.

The Concorde is to be built jointly by British and French aircraft makers. It will be able to fly from New York to London in 2½ hours, according to a Pan Am spokesman.

Reportedly the first Concorde is to be delivered about 1970.

The order was announced by Pan American President Juan Trippe at the close of a directors' meeting yesterday. It was confirmed by the French nationalized firm, Sud Aviation, which is developing the 1,400 m.p.h. plane in co-operation with the British Aircraft Corporation.

Although no price was given, estimates of the cost of supersonic airliners range from $8 million to over $15 million each. A United States supersonic airliner is expected to cost at least $15 million, but the price for a European-built craft would probably be a bit lower, according to airline authorities.

The United States has been talking about developing a supersonic plane for several years but has taken no firm action. Opinion among Government and aviation officials is that United States plane manufacturers cannot undertake the development without a Federal subsidy. Congress already has appropriated about $30 million to the Federal Aviation Agency for studies of the operating feasibility of a supersonic and its financing aspects.

A high-level intra-Government committee is expected to hand President Kennedy a recommendation shortly on whether the Government should subsidize development of the craft and, if so, how.

Pan Am's announcement is a breakthrough for the British-French supersonic plane.

United States plane makers ever since World War II have dominated the world market for passenger transport aircraft. However, Pan Am's decision seems to give the British-French effort a lead that a United States supersonic, if it is developed may find hard to overcome.

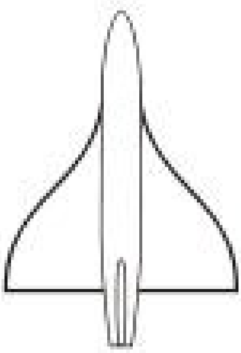
Pan Am, the largest United States flag international airline and one of the world's leading overseas air carriers, apparently decided to order the British-French supersonic to remain competitive with British Overseas Airways Corp. and Air France.

Evening Star June 05, 1963

Concorde
On the Wings Of Time

Ogee planform selected

Dietrich Küchemann and others at the RAE continued their work on the slender delta throughout this period, considering three basic shapes; the classic straight-edge delta, the "gothic delta" that was rounded outward to appear like a gothic arch, and the "ogival wing" that was compound-rounded into the shape of an ogee. Each of these planforms had its own advantages and disadvantages in terms of aerodynamics. As they worked with these shapes, a practical concern grew to become so important that it forced selection of one of these designs.

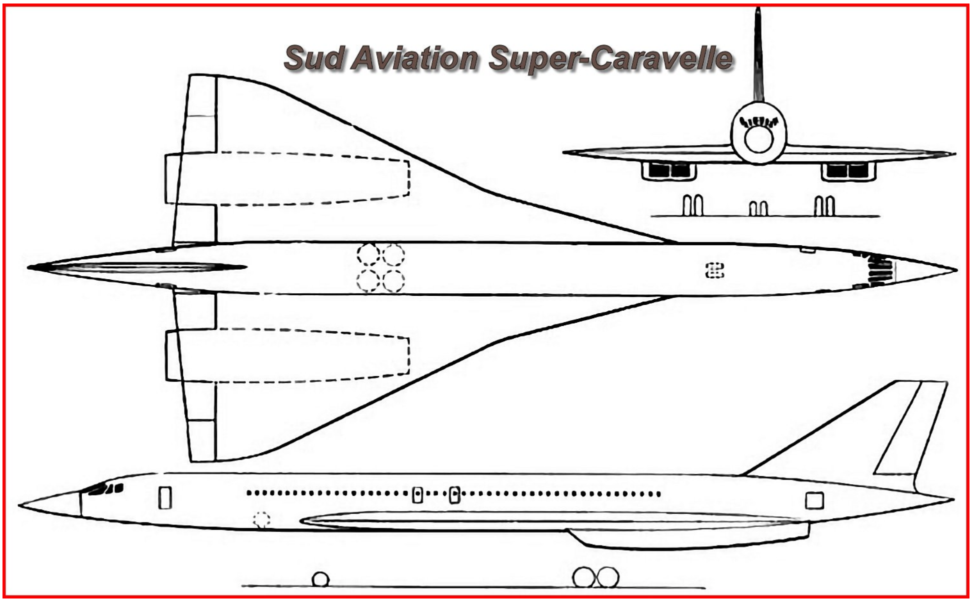


As the aircraft layout changes during the design phase, it is common for the Center of Gravity to move fore or aft. With a normal wing design this can be addressed by moving the wing slightly fore or aft to account for this. With a delta wing running most of the length of the fuselage, this was no longer easy; moving the wing would leave it in front of the nose or behind the tail. Studying the various layouts in terms of CG changes, both during design and changes due to fuel use during flight, the ogee planform immediately came to the fore.

To test the new wing, NASA privately assisted the team by modifying a Douglas F5D Skylancer with temporary wing modifications to mimic the wing selection. In 1965 the NASA test aircraft successfully tested the wing, and found that it reduced landing speeds noticeably over the standard delta wing. NASA Ames test center also ran simulations that showed the aircraft would suffer a sudden change in pitch when entering ground effect. Ames test pilots later participated in a joint cooperative test with the French and British test pilots and found that the simulations had been correct, and this information was added to pilot training.

Partnership with Sud Aviation

By this time similar political and economic concerns in France had led to their own SST plans. In the late 1950s the government requested designs from both the government-owned Sud Aviation and Nord Aviation, as well as Dassault. All three returned designs based on Dietrich Küchemann and Johanna Weber's slender delta; Nord suggested a ramjet powered design flying at Mach 3, the other two were jet powered Mach 2 designs that were similar to each other. Of the three, the Sud Aviation Super-Caravelle won the design contest with a medium-range design deliberately sized to avoid competition with transatlantic US designs they assumed were already on the drawing board.



As soon as the design was complete, in April 1960, Pierre Satre, the company's technical director, was sent to Bristol to discuss a partnership. Bristol was surprised to find that the Sud team had designed a similar aircraft after considering the SST problem and coming to the very same conclusions as the Bristol and STAC teams in terms of economics. It was later revealed that the original STAC report, marked "For UK Eyes Only", had secretly been passed to France to win political favour. Sud made minor changes to the paper, and presented it as their own work.

Unsurprisingly, the two teams found much to agree on. France had no modern large jet engines, and had already concluded they would buy a British design anyway (as they had on the earlier subsonic Caravelle). As neither company had experience in the use of high-heat metals for airframes, a maximum speed of around Mach 2 was selected so aluminium could be used – above this speed the friction with the air warms the metal so much that aluminium begins to soften. This lower speed would also speed development and allow their design to fly before the Americans. Finally, everyone involved agreed that Dietrich Küchemann's ogee shaped wing was the right one.

The only disagreements were over the size and range. The British team was still focused on a 150-passenger design serving transatlantic routes, while France was deliberately avoiding these. However, this proved not to be the barrier it might seem; common components could be used in both designs, with the shorter range version using a clipped fuselage and four engines, the longer one with a stretched fuselage and six engines, leaving only the wing to be extensively re-designed. The teams continued to meet through 1961, and by this time it was clear that the two aircraft would be considerably more similar in spite of different range and seating arrangements. A single design emerged that differed mainly in fuel load. More powerful Bristol Siddeley Olympus engines, being developed for the TSR-2, allowed either design to be powered by only four engines.

Cabinet response, treaty

While the development teams met, French Minister of Public Works and Transport Robert Buron was meeting with the UK Minister of Aviation Peter Thorneycroft, and Thorneycroft soon revealed to the cabinet that France was much more serious about a partnership than any of the US companies. The various US companies had proved uninterested in such a venture, likely due to the belief that the government would be funding development and would frown on any partnership with a European company, and the risk of "giving away" US technological leadership to a European partner.

When the STAC plans were presented to the UK cabinet, a negative reaction resulted. The economic considerations were considered highly questionable, especially as these were based on development costs, now estimated to be £150 million, which were repeatedly overrun in the industry.

The Treasury Ministry in particular presented a very negative view, suggesting that there was no way the project would have any positive financial returns for the government, especially in light that "the industry's past record of over-optimistic estimating (including the recent history of the TSR.2) suggests that it would be prudent to consider the £150 million [cost] to turn out much too low."

This concern led to an independent review of the project by the Committee on Civil Scientific Research and Development, which met on topic between July and September 1962. The committee ultimately rejected the economic arguments, including considerations of supporting the industry made by Peter Thorneycroft. Their report in October stated that it was unlikely there would be any direct positive economic outcome, but that the project should still be considered for the simple reason that everyone else was going supersonic, and they were concerned they would be locked out of future markets. Conversely, it appeared the project would not be likely to significantly affect other, more important, research efforts.

At the time, the UK was pressing for admission to the European Economic Community, and this became the main rationale for moving ahead with the aircraft. The development project was negotiated as an international treaty between the two countries rather than a commercial agreement between companies and included a clause, originally asked for by the UK government, imposing heavy penalties for cancellation. This treaty was signed on 29 November 1962. Charles De Gaulle would soon veto the UK's entry into the European Community in a speech on 25 January 1963.

Naming

Reflecting the treaty between the British and French governments that led to Concorde's construction, the name Concorde is from the French word concorde, which has an English equivalent, concord. Both words mean agreement, harmony, or union. The name was officially changed to Concord by Harold Macmillan in response to a perceived slight by Charles de Gaulle. At the French roll-out in Toulouse in late 1967, the British Government Minister of Technology, Tony Benn, announced that he would change the spelling back to Concorde. This created a nationalist uproar that died down when Benn stated that the suffixed "e" represented "Excellence, England, Europe, and Entente (Cordiale)".

Sales efforts

Described by Flight International as an "aviation icon" and "one of aerospace's most ambitious but commercially flawed projects", Concorde failed to meet its original sales targets, despite initial interest from several airlines. At first, the new consortium intended to produce one long-range and one short-range version. However, prospective customers showed no interest in the short-range version and it was dropped. A two-page advertisement for Concorde ran in the 29 May 1967 issue of Aviation Week & Space Technology which predicted a market for 350 aircraft by 1980 and boasted of Concorde's head start over the United States' SST project.

Concorde had considerable difficulties that led to its dismal sales performance. Costs had spiralled during development to more than six times the original projections, arriving at a unit cost of £23 million in 1977. Its sonic boom made travelling supersonically over land impossible without causing complaints from citizens. World events had also dampened Concorde sales prospects; the 1973–74 stock market crash and the 1973 oil crisis had made many airlines cautious about aircraft with high fuel consumption rates, and new wide-body aircraft, such as the Boeing 747, had recently made subsonic aircraft significantly more efficient and presented a low-risk option for airlines.

(**Note on the economic downturn**) The 1973–1974 stock market crash caused a bear market between January 1973 and December 1974. Affecting all the major stock markets in the world, particularly the United Kingdom, it was one of the worst stock market downturns since the Great Depression, the other being the financial crisis of 2007–2008. The crash came after the collapse of the "Bretton Woods system" over the previous two years, with the associated 'Nixon Shock' and United States dollar devaluation under the "Smithsonian Agreement". It was compounded by the outbreak of the 1973 oil crisis in October of that year. It was a major event of the 1970s recession.

The **Bretton Woods system** of monetary management established the rules for commercial and financial relations among the United States, Canada, Western European countries, Australia, and Japan after the 1944 Bretton Woods Agreement. The Bretton Woods system was the first example of a fully negotiated monetary order intended to govern monetary relations among independent states.

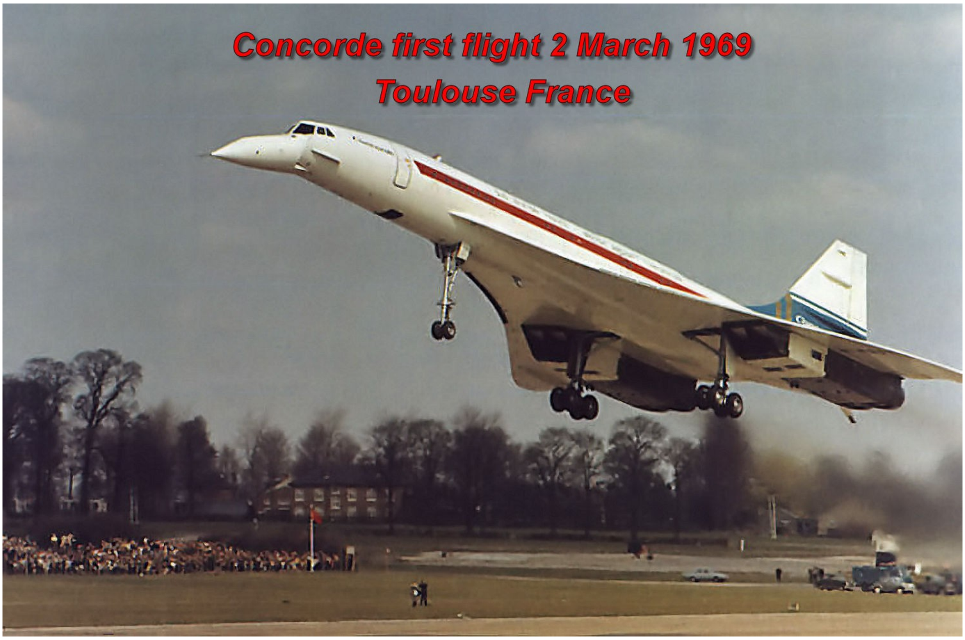
The Bretton Woods system required countries to guarantee convertibility of their currencies into U.S. dollars to within 1% of fixed parity rates, with the dollar convertible to gold bullion for foreign governments and central banks at US$35 per troy ounce of fine gold (or 0.88867 gram fine gold per dollar). It also envisioned greater cooperation among countries in order to prevent future competitive devaluations, and thus established the International Monetary Fund (IMF) to monitor exchange rates and lend reserve currencies to nations with balance of payments deficits.

The **Nixon shock** was a series of economic measures undertaken by United States President Richard Nixon in 1971, in response to increasing inflation, the most significant of which were wage and price freezes, surcharges on imports, and the unilateral cancellation of the direct international convertibility of the United States dollar to gold.

The **Smithsonian Agreement**, announced in December 1971, created a new dollar standard, whereby the currencies of a number of industrialized states were pegged to the US dollar. These currencies were allowed to fluctuate by 2.25% against the dollar. The Smithsonian Agreement was created when the Group of Ten (G-10) states (Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom, and the United States) raised the price of gold to 38 dollars, an 8.5% increase over the previous price at which the US government had promised to redeem dollars for gold. In effect, the changing gold price devalued the dollar by 7.9%

The consortium received orders, i.e., non-binding options, for more than 100 of the long-range version from the major airlines of the day: Pan Am, BOAC, and Air France were the launch customers, with six Concordes each. Other airlines in the order book included Panair do Brasil, Continental Airlines, Japan Airlines, Lufthansa, American Airlines, United Airlines, Air India, Air Canada, Braniff, Singapore Airlines, Iran Air, Olympic Airways, Qantas, CAAC Airlines, Middle East Airlines, and TWA. At the time of the first flight the options list contained 74 options from 16 airlines.

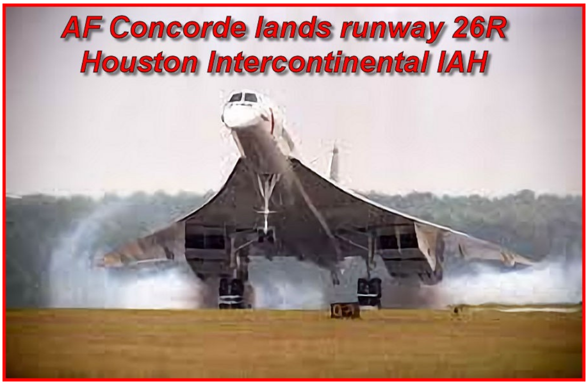
Testing



The design work was supported by a preceding research programme studying the flight characteristics of low ratio delta wings. A supersonic Fairey Delta 2 was modified to carry the planform, and, renamed as the BAC 221, used for flight tests of the high speed flight envelope, the Handley Page HP.115 also provided valuable information on low speed performance.

Construction of two prototypes began in February 1965: 001, built by Aérospatiale at Toulouse, and 002, by BAC at Filton, Bristol. Concorde 001 made its first test flight from Toulouse on 2 March 1969, piloted by André Turcat, and first went supersonic on 1 October. The first UK-built Concorde flew from Filton to RAF Fairford on 9 April 1969, piloted by Brian Trubshaw. Both prototypes were presented to the public for the first time on 7–8 June 1969 at the Paris Air Show.

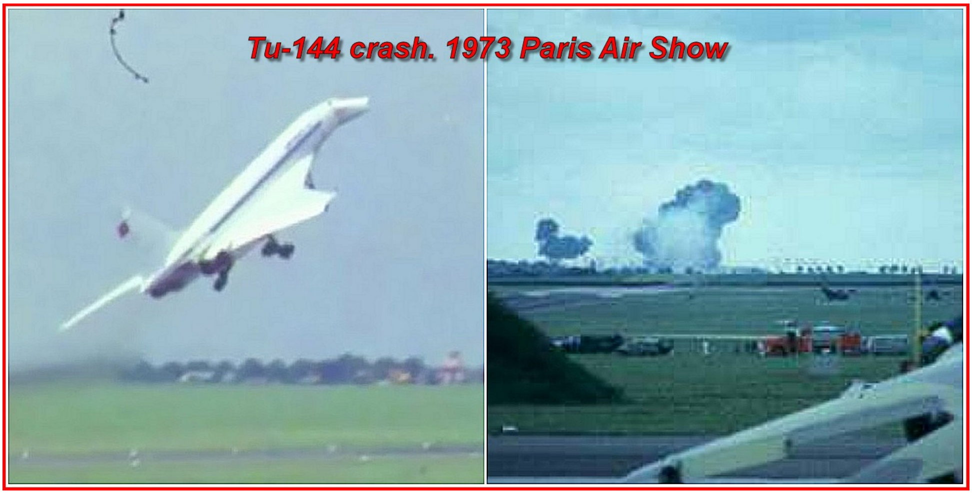
As the flight programme progressed, 001 embarked on a sales and demonstration tour on 4 September 1971, which was also the first transatlantic crossing of Concorde. Concorde 002 followed suit on 2 June 1972 with a tour of the Middle and Far East. Concorde 002 made the first visit to the United States in 1973, landing at the new Dallas/Fort Worth Regional Airport to mark that airport's opening.



(**Note**) The author, aircraft technician with Delta Airlines, was at the Delta hangar and saw the Air France Concorde land on runway 26R and taxi to the terminal. The pilots opened the cockpit windows and mounted small USA and French flags onto fuselage holders. After the display at the terminal, they taxied to the Delta Hangar ramp for refueling and maintenance inspections. I was awestruck when walking around under the fuselage and examining everything. The height of the landing gear, especially the nose strut, was really curious. At that time I was unaware of the design necessity of the high angle-of-attack needed for takeoff and landing, creating the upper wings vortex which produced a low-pressure area. The higher air pressure on the underside of the wings provided the upward lift.

B-777 cockpit. The author spent 15 years with Delta and 22 years with Continental as maintenance technician, avionics specialist and Maintenance Control Supervisor.

While Concorde had initially held a great deal of customer interest, the project was hit by a large number of order cancellations. The Paris Le Bourget air show crash of the competing Soviet Tupolev Tu-144 had shocked potential buyers, and public concern over the environmental issues presented by a supersonic aircraft—the sonic boom, take-off noise and pollution—had produced a shift in public opinion of SSTs. By 1976 the remaining buyers were from four countries: Britain, France, China, and Iran. Only Air France and British Airways (the successor to BOAC) took up their orders, with the two governments taking a cut of any profits made.


Tu-144 crash. 1973 Paris Air Show

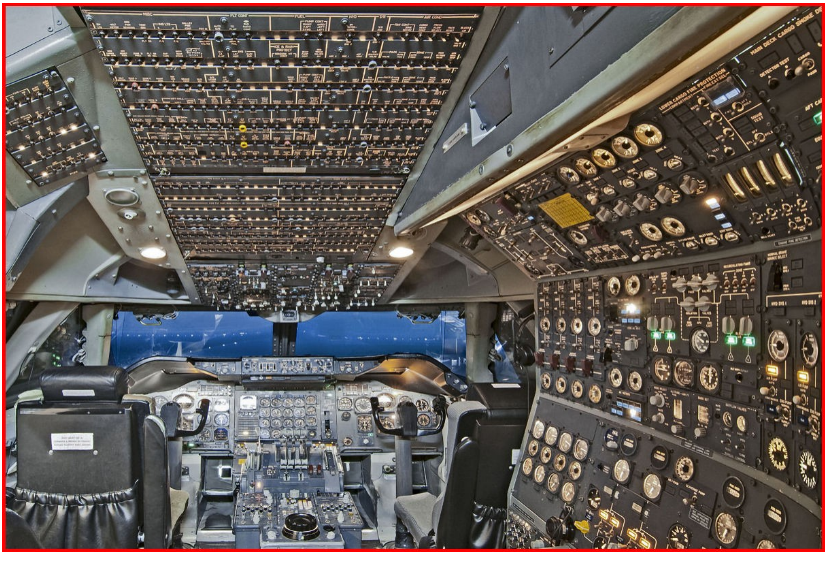
The 1973 Paris Air Show Tu-144 crash was the destruction of the second production Tupolev Tu-144 at Goussainville, Val-d'Oise, France, which killed all six crew members and eight people on the ground. The crash, at the Paris Air Show on Sunday, 3 June 1973, damaged the development program of the Tupolev Tu-144. One theory is that a French Mirage jet sent to photograph the aircraft without the knowledge of the Soviet crew caused the pilots to take evasive maneuvers, resulting in the crash. Another theory is that in a rivalry with the Anglo-French Concorde, the pilots attempted a maneuver that was beyond the capabilities of the aircraft.

The United States government cut federal funding for the Boeing 2707, its rival supersonic transport programme, in 1971; Boeing did not complete its two 2707 prototypes. The US, India, and Malaysia all ruled out Concorde supersonic flights over the noise concern, although some of these restrictions were later relaxed. Professor Douglas Ross characterised restrictions placed upon Concorde operations by President Jimmy Carter's administration as having been an act of protectionism of American aircraft manufacturers.

Programme cost

The original programme cost estimate was £70 million before 1962. The programme experienced huge cost overruns and delays, with the programme eventually costing between £1.5 and £2.1 billion in 1976. This extreme cost was the main reason the production run was much smaller than expected. The per-unit cost was impossible to recoup, so the French and British governments absorbed the development costs.

Design - Concorde flight deck layout



Concorde
On the Wings Of Time

General features

Concorde is an ogival delta winged aircraft with four Olympus engines based on those employed in the RAF's Avro Vulcan strategic bomber. It is one of the few commercial aircraft to employ a tailless design (the Tupolev Tu-144 being another). Concorde was the first airliner to have a (in this case, analogue) fly-by-wire flight-control system; the avionics system Concorde used was unique because it was the first commercial aircraft to employ hybrid circuits. The principal designer for the project was Pierre Satre, with Sir Archibald Russell as his deputy.

Sir Archibald Russell, desenhador do avião supersónico Concorde
16.00MT
Concorde
MOÇAMBIQUE
2013

Concorde pioneered the following technologies:

For high speed and optimisation of flight:

Double delta (ogee/ogival) shaped wings.

Variable engine air intake ramp system controlled by digital computers

Supercruise capability.

Thrust-by-wire engines, precursor of today's FADEC-controlled engines (Full Authority Digital Engine Control).

Droop nose for better landing visibility.

For weight-saving and enhanced performance:

Mach 2.02 (~2,154 km/h or 1,338 mph) cruising speed for optimum fuel consumption (supersonic drag minimum and turbojet engines are more efficient at higher speed) Fuel consumption at Mach 2 (2,120 km/h; 1,320 mph) and at altitude of 60,000 feet (18,000 m) was 4,800 US gallons per hour (18,000 L/h).

Mainly aluminium construction using a high temperature alloy similar to that developed for aero-engine pistons. This material gave low weight and allowed conventional manufacture (higher speeds would have ruled out aluminium)

Full-regime autopilot and autothrottle allowing "hands off" control of the aircraft from climb out to landing.

Fully electrically controlled analogue fly-by-wire flight controls systems.

High-pressure hydraulic system using 28 MPa (4,100 psi) for lighter hydraulic components, tripled independent systems ("Blue", "Green", and "Yellow") for redundancy, with an emergency ram air turbine (RAT) stored in the port (left) inner elevon jack fairing supplying "Green" and "Yellow" hydraulic systems as backup.

Complex air data computer (ADC) for the automated monitoring and transmission of aerodynamic measurements (total air pressure, static air pressure, angle of attack (nose up, nose down), side-slip.

Fully electrically controlled analogue brake-by-wire system. (Autobrakes on landing)

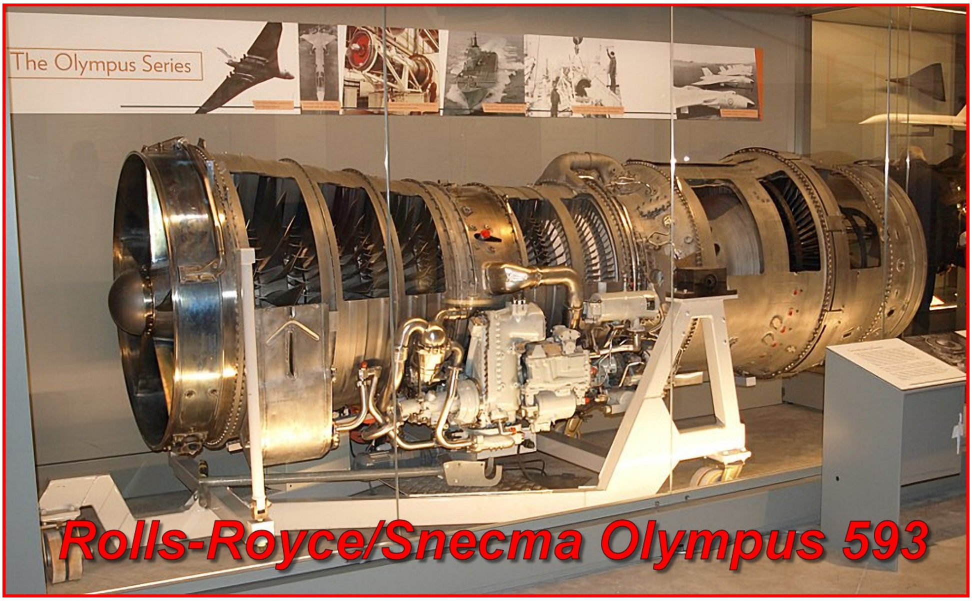
Pitch trim (nose up, nose down) by shifting fuel fore-and-aft for centre-of-gravity (CG) control at the approach to Mach 1 and above with no drag penalty. Pitch trimming by fuel transfer had been used since 1958 on the B-58 supersonic bomber.

Parts made using "sculpture milling", reducing the part count while saving weight and adding strength.

(**Note**) The strength and weight of the wings were very important in the design and construction. Instead of bolting and riveting sections together, the engineers used a process known as sculpture milling that starts off as a solid piece of metal. After that they used a numerically controlled milling machine to carve out the shapes needed. The material used for this was copper-based aluminum alloy, known as RR58 in the UK and AU2GN in France.

No auxiliary power unit (APU), as Concorde would only visit large airports where ground air start carts and electrical power cables are available.

Powerplant



Rolls-Royce/Snecma Olympus 593

A symposium titled "Supersonic-Transport Implications" was hosted by the Royal Aeronautical Society on 8 December 1960. Various views were put forward on the likely type of powerplant for a supersonic transport, such as podded or buried installation and turbojet or ducted-fan engines. Boundary layer management in the podded installation was put forward as simpler with only an inlet cone but Dr. Seddon of the RAE saw "a future in a more sophisticated integration of shapes" in a buried installation.

(**Note**) What does SNECMA stand for? Société nationale d'études et de construction de moteurs d'aviation (National Company for the Research and Construction of Aviation Engines') In 1945 the French nationalized the Gnome & Rhône engine manufacturer from which the name SNECMA came.

Another concern highlighted the case with two or more engines situated behind a single intake. An intake failure could lead to a double or triple engine failure. The advantage of the ducted fan over the turbojet was reduced airport noise but with considerable economic penalties with its larger cross-section producing excessive drag. At that time it was considered that the noise from a turbojet optimised for supersonic cruise could be reduced to an acceptable level using noise suppressors as used on subsonic jets.

The powerplant configuration selected for Concorde, and its development to a certificated design, can be seen in light of the above symposium topics (which highlighted airfield noise, boundary layer management and interactions between adjacent engines) and the requirement that the powerplant, at Mach 2, tolerate combinations of pushovers (nose down), sideslips, pull-ups and throttle slamming without surging.

Extensive development testing with design changes and changes to intake and engine control laws would address most of the issues except airfield noise and the interaction between adjacent powerplants at speeds above Mach 1.6 which meant Concorde "had to be certified aerodynamically as a twin-engined aircraft above Mach 1.6".

Rolls-Royce had a design proposal, the RB.169, for the aircraft at the time of Concorde's initial design but "to develop a brand-new engine for Concorde would have been prohibitively expensive" so an existing engine, already flying in the supersonic BAC TSR-2 strike bomber prototype, was chosen. It was the BSEL Olympus Mk 320 turbojet, a development of the Bristol engine first used for the subsonic Avro Vulcan bomber.

Avro Hawker Vulcan Bomber

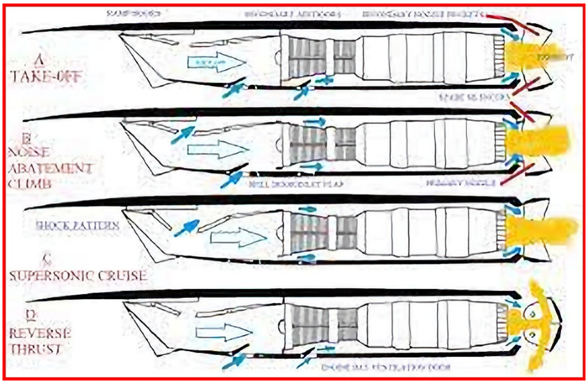
Great confidence was placed in being able to reduce the noise of a turbojet and massive strides by SNECMA in silencer design were reported during the programme. However, by 1974 the spade silencers which projected into the exhaust were reported to be ineffective but "entry-into-service aircraft are likely to meet their noise guarantees". The Olympus Mk.622 with reduced jet velocity was proposed to reduce the noise but it was not developed.

Situated behind the leading edge of the wing, the engine intake had a wing boundary layer ahead of it. Two-thirds was diverted and the remaining third which entered the intake did not adversely affect the intake efficiency except during pushovers (nose overs) when the boundary layer thickened ahead of the intake and caused surging. Extensive wind tunnel testing helped define leading edge modifications ahead of the intakes which solved the problem.

Each engine had its own intake and the engine nacelles were paired with a splitter plate between them to minimise adverse behaviour of one powerplant influencing the other. Only above Mach 1.6 (1,960 km/h; 1,220 mph) was an engine surge likely to affect the adjacent engine. Concorde needed to fly long distances to be economically viable; this required high efficiency from the powerplant. Turbofan engines were rejected due to their larger cross-section producing excessive drag. Olympus turbojet technology was available to be developed to meet the design requirements of the aircraft, although turbofans would be studied for any future SST.

The aircraft used reheat (afterburners) only at take-off and to pass through the upper transonic regime to supersonic speeds, between Mach 0.95 and 1.7. Reheat was switched off at all other times. Due to jet engines being highly inefficient at low speeds, Concorde burned two tonnes (4,400 lb) of fuel (almost 2% of the maximum fuel load) taxiing to the runway. Fuel used was Jet A-1. Due to the high thrust produced even with the engines at idle, only the two outer engines were run after landing for easier taxiing and less brake pad wear – at low weights after landing, the aircraft would not remain stationary with all four engines idling requiring the brakes to be continuously applied to prevent the aircraft from rolling.

The air intake design for Concorde's engines was especially critical. The intakes had to slow down supersonic inlet air to subsonic speeds with high pressure recovery to ensure efficient operation at cruising speed while providing low distortion levels (to prevent engine surge) and maintaining high efficiency for all likely ambient temperatures to be met in cruise. They had to provide adequate subsonic performance for diversion cruise and low engine-face distortion at take-off. They also had to provide an alternative path for excess intake air during engine throttling or shutdowns. The variable intake features required to meet all these requirements consisted of front and rear ramps, a dump door, an auxiliary inlet and a ramp bleed to the exhaust nozzle. As well as supplying air to the engine, the intake also supplied air through the ramp bleed to the propelling nozzle. The nozzle ejector (or aerodynamic) design, with variable exit area and secondary flow from the intake, contributed to good expansion efficiency from take-off to cruise.

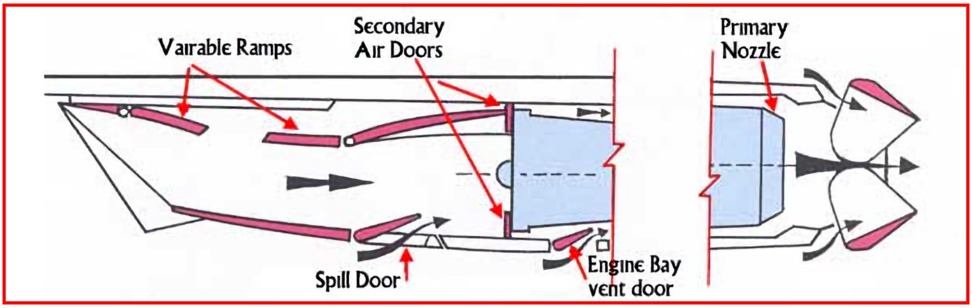


Concorde's Air Intake Control Units (AICUs) made use of a digital processor to provide the necessary accuracy for intake control. It was the world's first use of a digital processor to be given full authority control of an essential system in a passenger aircraft. It was developed by the Electronics and Space Systems (ESS) division of the British Aircraft Corporation after it became clear that the analogue AICUs fitted to the prototype aircraft and developed by Ultra Electronics were found to be insufficiently accurate for the tasks in hand.

(**Note**) On September 13, 1985, Concorde landed for the first time in French Polynesia, more precisely in Moruroa. In 1989 the author, with his wife Lydia, was vacationing in Tahiti. While lounging by the pool at the Maeva Beach Hotel, the Concorde's engines could be heard from nearby Faa'a airport. Shortly afterward, the Concorde appeared above the blue Pacific on its way to Sydney Australia. It then banked left-wing down and the wonderous view of the brilliant white delta wings and fuselage against the deep blue sky is still clearly etched in mind as if only yesterday.

Concorde
On the Wings Of Time

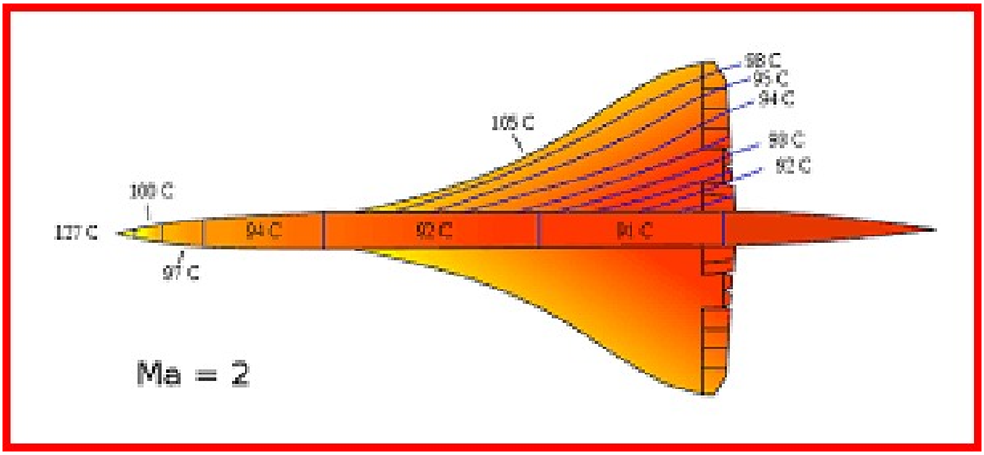
Engine failure causes problems on conventional subsonic aircraft; not only does the aircraft lose thrust on that side but the engine creates drag, causing the aircraft to yaw and bank in the direction of the failed engine. If this had happened to Concorde at supersonic speeds, it theoretically could have caused a catastrophic failure of the airframe. Although computer simulations predicted considerable problems, in practice Concorde could shut down both engines on the same side of the aircraft at Mach 2 without the predicted difficulties. During an engine failure the required air intake is virtually zero. So, on Concorde, engine failure was countered by the opening of the auxiliary spill door and the full extension of the ramps, which deflected the air downwards past the engine, gaining lift and minimising drag. Concorde pilots were routinely trained to handle double engine failure.



Heating problems

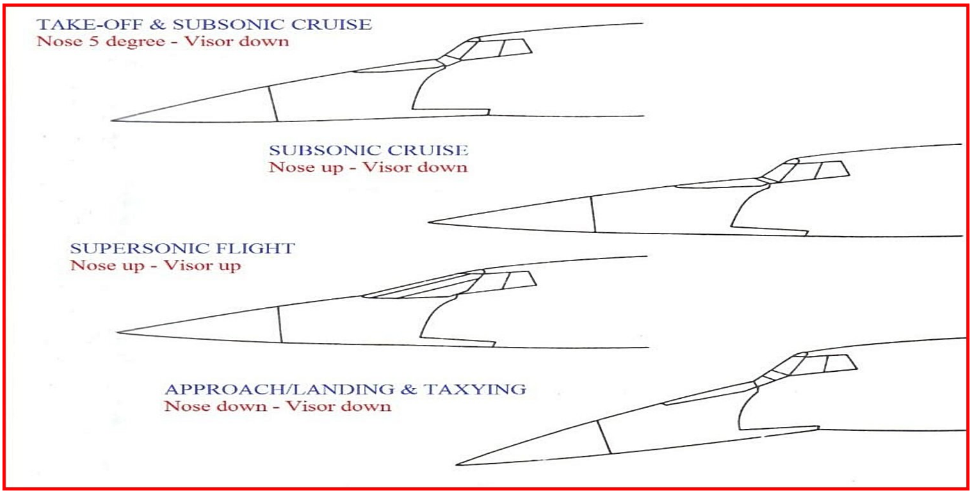
Air compression on the outer surfaces caused the cabin to heat up during flight. Every surface, such as windows and panels, was warm to the touch by the end of the flight. Besides engines, the hottest part of the structure of any supersonic aircraft is the nose, due to aerodynamic heating. The engineers used Hiduminium R.R. 58, an aluminium alloy, throughout the aircraft because of its familiarity, cost and ease of construction. The highest temperature that aluminium could sustain over the life of the aircraft was 127 °C (261 °F), which limited the top speed to Mach 2.02. Concorde went through two cycles of heating and cooling during a flight, first cooling down as it gained altitude, then heating up after going supersonic. The reverse happened when descending and slowing down. This had to be factored into the metallurgical and fatigue modelling.

A test rig was built that repeatedly heated up a full-size section of the wing, and then cooled it, and periodically samples of metal were taken for testing. The Concorde airframe was designed for a life of 45,000 flying hours.

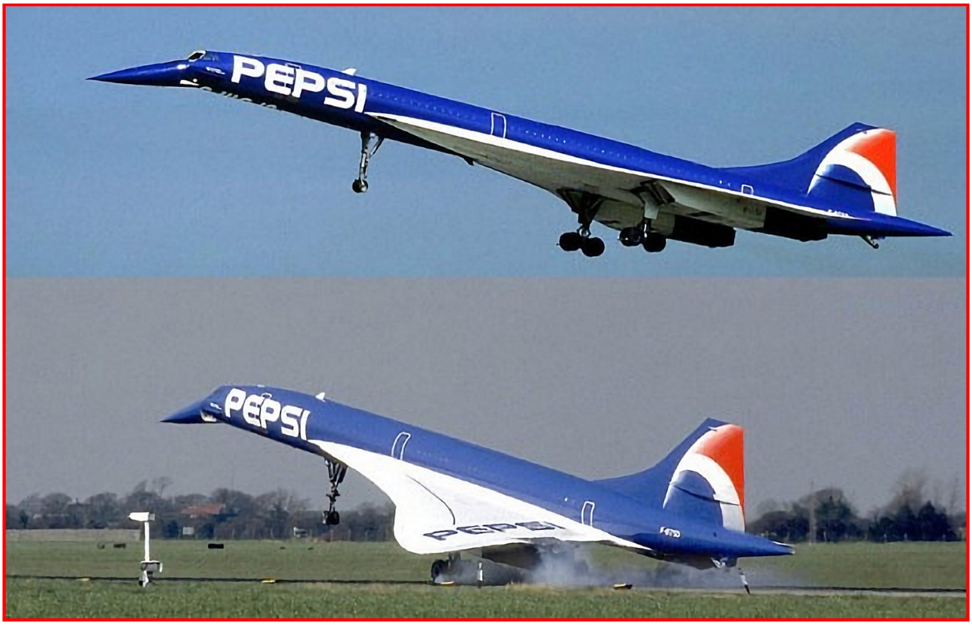


Concorde skin temperatures

Owing to air compression in front of the plane as it travelled at supersonic speed, the fuselage heated up and expanded by as much as 300 mm (12 in). The most obvious manifestation of this was a gap that opened up on the flight deck between the flight engineer's console and the bulkhead. On some aircraft that conducted a retiring supersonic flight, the flight engineers placed their caps in this expanded gap, wedging the cap when the airframe shrank again. To keep the cabin cool, Concorde used the fuel as a heat sink for the heat from the air conditioning. The same method also cooled the hydraulics. During supersonic flight the surfaces forward from the cockpit became heated, and a visor was used to deflect much of this heat from directly reaching the cockpit.



Concorde had livery restrictions; the majority of the surface had to be covered with a highly reflective white paint to avoid overheating the aluminium structure due to heating effects from supersonic flight at Mach 2. The white finish reduced the skin temperature by 6 to 11 °C (11 to 20 °F). In 1996, Air France briefly painted F-BTSD in a predominantly blue livery, with the exception of the wings, in a promotional deal with Pepsi. In this paint scheme, Air France was advised to remain at Mach 2 (2,120 km/h; 1,320 mph) for no more than 20 minutes at a time, but there was no restriction at speeds under Mach 1.7. F-BTSD was used because it was not scheduled for any long flights that required extended Mach 2 operations.

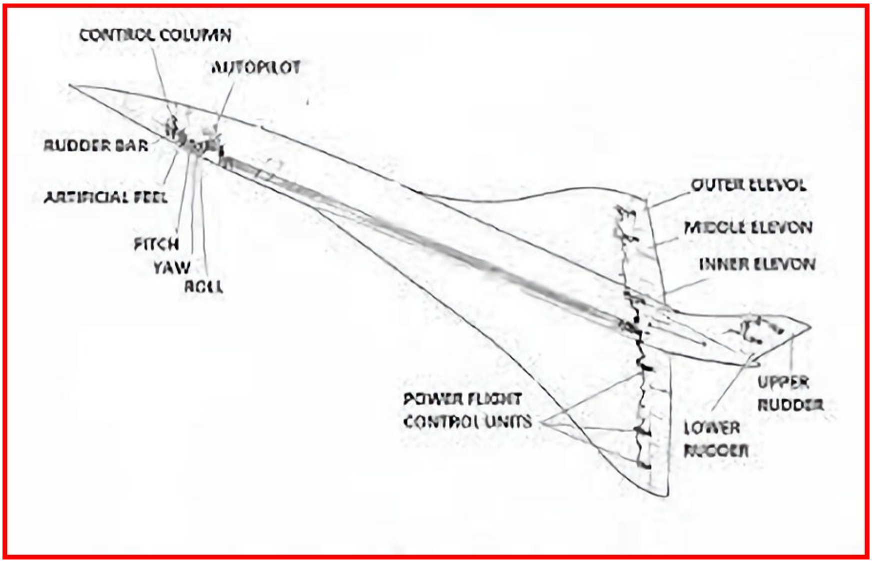


(**Note**) For two weeks in 1996, it bore a unique, blue livery as part of an advertising deal with soft drinks giant Pepsi. However, this unique paint scheme would hinder its performance levels, and restrict the routes it could fly. The promotional livery came about at a time when Pepsi was rebranding its products with a new color scheme. This was, of course, the blue, red, and white combination that is instantly recognizable today. In order to bring this to the attention of the world, the soft drinks giant embarked on a $500 million marketing project.

The Independent described this as "a bold, perhaps desperate gamble." One aspect of this expensive marketing drive was to repaint a supersonic Aérospatiale BAC Concorde airliner in Pepsi's new color scheme. As one of the most revered and exclusive airliners in the skies at the time, this was sure to be a bold statement that would draw extensive publicity for the company. The Aviation Geek Club reports that Pepsi approached both Concorde operators, Air France and British Airways, with its audacious proposal. A promotional deal was eventually agreed upon with the French flag carrier. Over two weeks in March and April 1996, the aircraft operated 16 flights in its conspicuous temporary livery.

Structural issues

Due to its high speeds, large forces were applied to the aircraft during banks and turns, and caused twisting and distortion of the aircraft's structure. In addition there were concerns over maintaining precise control at supersonic speeds. Both of these issues were resolved by active ratio changes between the inboard and outboard elevons, varying at differing speeds including supersonic. Only the innermost elevons, which are attached to the stiffest area of the wings, were active at high speed. Additionally, the narrow fuselage meant that the aircraft flexed. This was visible from the rear passengers' viewpoints.



When any aircraft passes the critical mach of that particular airframe, the centre of pressure shifts rearwards. This causes a pitch down moment on the aircraft if the centre of gravity remains where it was. The engineers designed the wings in a specific manner to reduce this shift, but there was still a shift of about 2 metres (6 ft 7 in). This could have been countered by the use of trim controls, but at such high speeds this would have dramatically increased drag. Instead, the distribution of fuel along the aircraft was shifted during acceleration and deceleration to move the centre of gravity (CG), effectively acting as an auxiliary trim control.

Range

To fly non-stop across the Atlantic Ocean, Concorde required the greatest supersonic range of any aircraft. This was achieved by a combination of engines which were highly efficient at supersonic speeds, a slender fuselage with high fineness ratio, and a complex wing shape for a high lift-to-drag ratio. This also required carrying only a modest payload and a high fuel capacity, and the aircraft was trimmed to avoid unnecessary drag.

Nevertheless, soon after Concorde began flying, a Concorde "B" model was designed with slightly larger fuel capacity and slightly larger wings with leading edge slats to improve aerodynamic performance at all speeds, with the objective of expanding the range to reach markets in new regions. It featured more powerful engines with sound deadening and without the fuel-hungry and noisy afterburner. It was speculated that it was reasonably possible to create an engine with up to 25% gain in efficiency over the Rolls-Royce/Snecma Olympus 593. This would have given 500 mi (805 km) additional range and a greater payload, making new commercial routes possible. This was cancelled due in part to poor sales of Concorde, but also to the rising cost of aviation fuel in the 1970s.

British Airways Concorde interior

Radiation concerns

Concorde's high cruising altitude meant people on board received almost twice the flux of extraterrestrial ionising radiation as those travelling on a conventional long-haul flight. Upon Concorde's introduction, it was speculated that this exposure during supersonic travels would increase the likelihood of skin cancer. Due to the proportionally reduced flight time, the overall equivalent dose would normally be less than a conventional flight over the same distance. Unusual solar activity might lead to an increase in incident radiation. To prevent incidents of excessive radiation exposure, the flight deck had a radiometer and an instrument to measure the rate of increase or decrease of radiation. If the radiation level became too high, Concorde would descend below 47,000 feet (14,000 m).

Cabin pressurisation

Airliner cabins were usually maintained at a pressure equivalent to 6,000–8,000 feet (1,800–2,400 m) elevation. Concorde's pressurisation was set to an altitude at the lower end of this range, 6,000 feet (1,800 m). Concorde's maximum cruising altitude was 60,000 feet (18,000 m); subsonic airliners typically cruise below 44,000 feet (13,000 m).

A sudden reduction in cabin pressure is hazardous to all passengers and crew. Above 50,000 feet (15,000 m), a sudden cabin depressurisation would leave a "time of useful consciousness" up to 10–15 seconds for a conditioned athlete. At Concorde's altitude, the air density is very low; a breach of cabin integrity would result in a loss of pressure severe enough that the plastic emergency oxygen masks installed on other passenger jets would not be effective and passengers would soon suffer from hypoxia despite quickly donning them. Concorde was equipped with smaller windows to reduce the rate of loss in the event of a breach, a reserve air supply system to augment cabin air pressure, and a rapid descent procedure to bring the aircraft to a safe altitude. The FAA enforces minimum emergency descent rates for aircraft and noting Concorde's higher operating altitude, concluded that the best response to pressure loss would be a rapid descent. Continuous positive airway pressure would have delivered pressurised oxygen directly to the pilots through masks.

Flight characteristics

While subsonic commercial jets took eight hours to fly from Paris to New York (seven hours from New York to Paris), the average supersonic flight time on the transatlantic routes was just under 3.5 hours. Concorde had a maximum cruising altitude of 18,300 metres (60,000 ft) and an average cruise speed of Mach 2.02 (2,150 km/h; 1,330 mph), more than twice the speed of conventional aircraft.

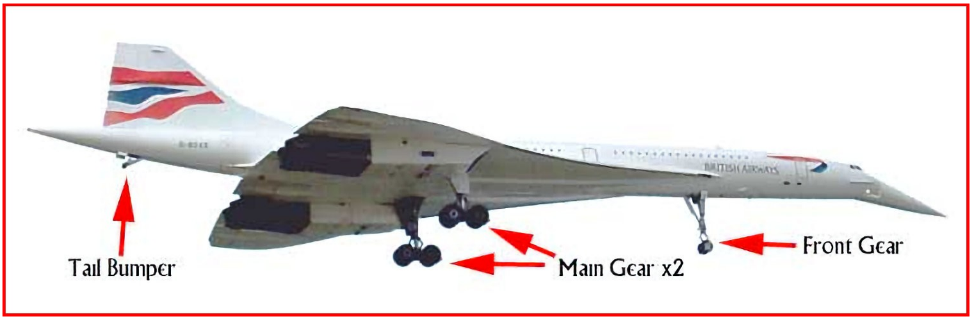
With no other civil traffic operating at its cruising altitude of about 56,000 ft (17,000 m), Concorde had exclusive use of dedicated oceanic airways, or "tracks", separate from the North Atlantic Tracks, the routes used by other aircraft to cross the Atlantic. Due to the significantly less variable nature of high altitude winds compared to those at standard cruising altitudes, these dedicated SST tracks had fixed co-ordinates, unlike the standard routes at lower altitudes, whose co-ordinates are replotted twice daily based on forecast weather patterns (jetstreams).

Concorde would also be cleared in a 15,000-foot (4,570 m) block, allowing for a slow climb from 45,000 to 60,000 ft (14,000 to 18,000 m) during the oceanic crossing as the fuel load gradually decreased. In regular service, Concorde employed an efficient cruise-climb flight profile following take-off.

The delta-shaped wings required Concorde to adopt a higher angle of attack at low speeds than conventional aircraft, but it allowed the formation of large low pressure vortices over the entire upper wing surface, maintaining lift. The normal landing speed was 170 miles per hour (274 km/h). Because of this high angle, during a landing approach Concorde was on the "back side" of the drag force curve, where raising the nose would increase the rate of descent; the aircraft was thus largely flown on the throttle and was fitted with an autothrottle to reduce the pilot's workload.

“The only thing that tells you that you're moving is that occasionally when you're flying over the subsonic aeroplanes you can see all these 747s 20,000 feet below you almost appearing to go backwards, I mean you are going 800 miles an hour or thereabouts faster than they are. The aeroplane was an absolute delight to fly, it handled beautifully. And remember we are talking about an aeroplane that was being designed in the late 1950s – mid 1960s. I think it's absolutely amazing and here we are, now in the 21st century, and it remains unique.” — John Hutchinson, Concorde Captain, "The World's Greatest Airliner" (2003)

Because of the way Concorde's delta-wing generated lift, the undercarriage had to be unusually strong and tall to allow for the angle of attack at low speed. At rotation, Concorde would rise to a high angle of attack, about 18 degrees. Prior to rotation the wing generated almost no lift, unlike typical aircraft wings. Combined with the high airspeed at rotation (199 knots or 369 kilometres per hour or 229 miles per hour indicated airspeed), this increased the stresses on the main undercarriage in a way that was initially unexpected during the development and required a major redesign. Due to the high angle needed at rotation, a small set of wheels was added aft to prevent tailstrikes. The main undercarriage units swing towards each other to be stowed but due to their great height also needed to contract in length telescopically before swinging to clear each other when stowed.

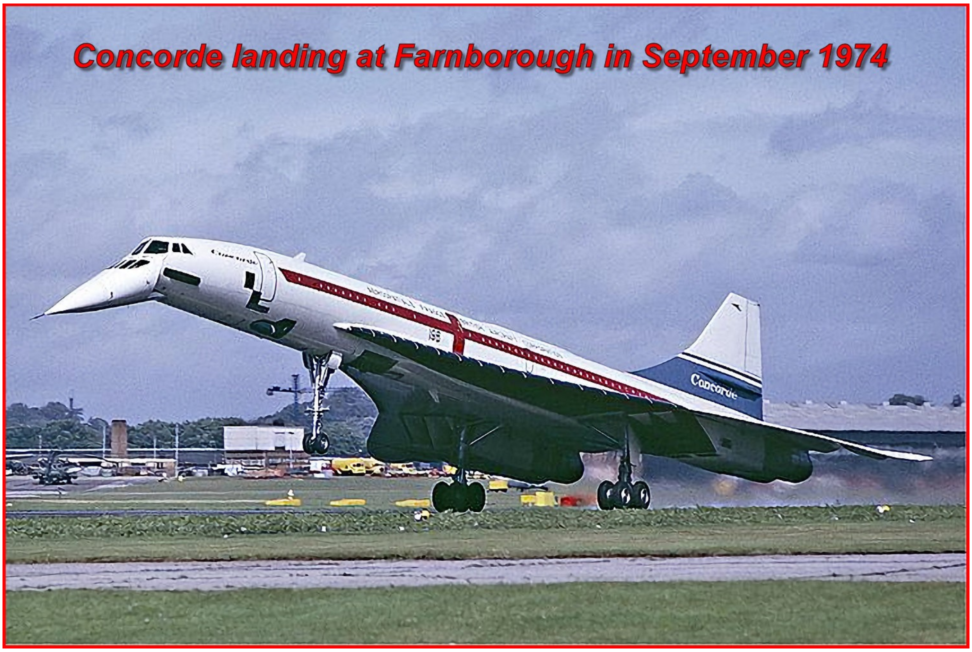


The four main wheel tyres on each bogie unit are inflated to 232 psi (1,600 kPa). The twin-wheel nose undercarriage retracts forwards and its tyres are inflated to a pressure of 191 psi (1,320 kPa), and the wheel assembly carries a spray deflector to prevent standing water being thrown up into the engine intakes. The tyres are rated to a maximum speed on the runway of 250 mph (400 km/h). The starboard nose wheel carries a single disc brake to halt wheel rotation during retraction of the undercarriage. The port nose wheel carries speed generators for the anti-skid braking system which prevents brake activation until nose and main wheels rotate at the same rate.

Additionally, due to the high average take-off speed of 250 miles per hour (400 km/h), Concorde needed upgraded brakes. Like most airliners, Concorde has anti-skid braking – a system which prevents the tyres from losing traction when the brakes are applied for greater control during roll-out. The brakes, developed by Dunlop, were the first carbon-based brakes used on an airliner. The use of carbon over equivalent steel brakes provided a weight-saving of 1,200 lb (540 kg). Each wheel has multiple discs which are cooled by electric fans. Wheel sensors include brake overload, brake temperature, and tyre deflation. After a typical landing at Heathrow, brake temperatures were around 300–400 °C (570–750 °F). Landing Concorde required a minimum of 6,000 feet (1,800 m) runway length, this in fact being considerably less than the shortest runway Concorde ever actually landed on carrying commercial passengers, that of Cardiff Airport. Concorde G-AXDN (101), however, made its final landing at Duxford Aerodrome on 20 August 1977, which had a runway length of just 6,000 feet (1,800 m) at the time. This was the final aircraft to land at Duxford before the runway was shortened later that year.

Droop nose

Concorde's drooping nose, developed by Marshall's of Cambridge, enabled the aircraft to switch from being streamlined to reduce drag and achieve optimal aerodynamic efficiency during flight, to not obstructing the pilot's view during taxi, take-off, and landing operations. Due to the high angle of attack, the long pointed nose obstructed the view and necessitated the ability to droop. The droop nose was accompanied by a moving visor that retracted into the nose prior to being lowered. When the nose was raised to horizontal, the visor would rise in front of the cockpit windscreen for aerodynamic streamlining.


Concorde landing at Farnborough in September 1974

A controller in the cockpit allowed the visor to be retracted and the nose to be lowered to 5° below the standard horizontal position for taxiing and take-off. Following take-off and after clearing the airport, the nose and visor were raised. Prior to landing, the visor was again retracted and the nose lowered to 12.5° below horizontal for maximal visibility. Upon landing the nose was raised to the 5° position to avoid the possibility of damage due to collision with ground vehicles, and then raised fully before engine shutdown to prevent pooling of internal condensation within the radome seeping down into the aircraft's pitot/ADC system probes. The US Federal Aviation Administration had objected to the restrictive visibility of the visor used on the first two prototype Concordes, which had been designed before a suitable high-temperature window glass had become available, and thus requiring alteration before the FAA would permit Concorde to serve US airports. This led to the redesigned visor used on the production and the four pre-production aircraft (101, 102, 201, and 202). The nose window and visor glass, needed to endure temperatures in excess of 100 °C (210 °F) at supersonic flight, were developed by Triplex.

1973 Solar Eclipse Mission

Concorde 001 was modified with rooftop portholes for use on the 1973 Solar Eclipse mission and equipped with observation instruments. It performed the longest observation of a solar eclipse to date, about 74 minutes.

Scheduled flights

Scheduled flights began on 21 January 1976 on the London–Bahrain and Paris–Rio de Janeiro (via Dakar) routes, with BA flights using the Speedbird Concorde call sign to notify air traffic control of the aircraft's unique abilities and restrictions, but the French using their normal call signs. The Paris-Caracas route (via Azores) began on 10 April. The US Congress had just banned Concorde landings in the US, mainly due to citizen protest over sonic booms, preventing launch on the coveted North Atlantic routes. The US Secretary of Transportation, William Coleman, gave permission for Concorde service to Washington Dulles International Airport, and Air France and British Airways simultaneously began a thrice-weekly service to Dulles on 24 May 1976. Due to low demand, Air France cancelled its Washington service in October 1982, while British Airways cancelled it in November 1994.

When the US ban on JFK Concorde operations was lifted in February 1977, New York banned Concorde locally. The ban came to an end on 17 October 1977 when the Supreme Court of the United States declined to overturn a lower court's ruling rejecting efforts by the Port Authority of New York and New Jersey and a grass-roots campaign led by Carol Berman to continue the ban.

In December 1977, British Airways and Singapore Airlines started sharing a Concorde for flights between London and Singapore International Airport at Paya Lebar via Bahrain. The aircraft, BA's Concorde G-BOAD, was painted in Singapore Airlines livery on the port side and British Airways livery on the starboard side. The service was discontinued after three return flights because of noise complaints from the Malaysian government; it could only be reinstated on a new route bypassing Malaysian airspace in 1979. A dispute with India prevented Concorde from reaching supersonic speeds in Indian airspace, so the route was eventually declared not viable and discontinued in 1980.

During the Mexican oil boom, Air France flew Concorde twice weekly to Mexico City's Benito Juárez International Airport via Washington, DC, or New York City, from September 1978 to November 1982. The worldwide economic crisis during that period resulted in this route's cancellation; the last flights were almost empty. The routing between Washington or New York and Mexico City included a deceleration, from Mach 2.02 to Mach 0.95, to cross Florida subsonically and avoid creating a sonic boom over the state; Concorde then re-accelerated back to high speed while crossing the Gulf of Mexico. On 1 April 1989, on an around-the-world luxury tour charter, British Airways implemented changes to this routing that allowed G-BOAF to maintain Mach 2.02 by passing around Florida to the east and south. Periodically Concorde visited the region on similar chartered flights to Mexico City and Acapulco.

From December 1978 to May 1980, Braniff International Airways leased 11 Concordes, five from Air France and six from British Airways. These were used on subsonic flights between Dallas–Fort Worth and Washington Dulles International Airport, flown by Braniff flight crews. Air France and British Airways crews then took over for the continuing supersonic flights to London and Paris. The aircraft were registered in both the United States and their home countries; the European registration was covered while being operated by Braniff, retaining full AF/BA liveries. The flights were not profitable and typically less than 50% booked, forcing Braniff to end its tenure as the only US Concorde operator in May 1980.

In its early years, the British Airways Concorde service had a greater number of "no shows" (passengers who booked a flight and then failed to appear at the gate for boarding) than any other aircraft in the fleet.

Following the launch of British Airways Concorde services, Britain's other major airline, British Caledonian (BCal), set up a task force headed by Gordon Davidson, BA's former Concorde director, to investigate the possibility of their own Concorde operations. This was seen as particularly viable for the airline's long-haul network as there were two unsold aircraft then available for purchase. One important reason for BCal's interest in Concorde was that the British Government's 1976 aviation policy review had opened the possibility of BA setting up supersonic services in competition with BCal's established sphere of influence. To counteract this potential threat, BCal considered their own independent Concorde plans, as well as a partnership with BA. BCal were considered most likely to have set up a Concorde service on the Gatwick–Lagos route, a major source of revenue and profits within BCal's scheduled route network; BCal's Concorde task force did assess the viability of a daily supersonic service complementing the existing subsonic widebody service on this route.

British Airways buys its Concordes outright

By around 1981 in the UK, the future for Concorde looked bleak. The British government had lost money operating Concorde every year, and moves were afoot to cancel the service entirely. A cost projection came back with greatly reduced metallurgical testing costs because the test rig for the wings had built up enough data to last for 30 years and could be shut down. Despite this, the government was not keen to continue. In 1983, BA's managing director, Sir John King, convinced the government to sell the aircraft outright to the then state-owned British Airways for £16.5 million plus the first year's profits. In 2003, Lord Heseltine, who was the minister responsible at the time, revealed to Alan Robb on BBC Radio 5 Live, that the aircraft had been sold for "next to nothing". Asked by Robb if it was the worst deal ever negotiated by a government minister, he replied "That is probably right. But if you have your hands tied behind your back and no cards and a very skillful negotiator on the other side of the table... I defy you to do any [better]." British Airways was privatised in 1987.

The speed and premium service were relatively costly: in 1997, the round-trip ticket price from New York to London was $7,995, more than 30 times the cost of the least expensive scheduled flight for this route, however when compared with subsonic First Class on the same route, return tickets were only about 10-15% more expensive while flight time was cut in half.

Retirement

On 10 April 2003, Air France and British Airways simultaneously announced they would retire Concorde later that year. They cited low passenger numbers following the 25 July 2000 crash, the slump in air travel following the September 11 attacks, and rising maintenance costs: Airbus, the company that acquired Aérospatiale in 2000, had made a decision in 2003 to no longer supply replacement parts for the aircraft.

Although Concorde was technologically advanced when introduced in the 1970s, 30 years later, its analogue cockpit was outdated. There had been little commercial pressure to upgrade Concorde due to a lack of competing aircraft, unlike other airliners of the same era such as the Boeing 747. By its retirement, it was the last aircraft in the British Airways fleet that had a flight engineer; other aircraft, such as the modernised 747-400, had eliminated the role.

It has been suggested that Concorde was not withdrawn for the reasons usually given but that it became apparent during the grounding of Concorde that the airlines could make more profit carrying first-class passengers subsonically. A lack of commitment to Concorde from Director of Engineering Alan MacDonald was cited as having undermined BA's resolve to continue operating Concorde.

Concorde
On the Wings Of Time

Air France Flight 4590

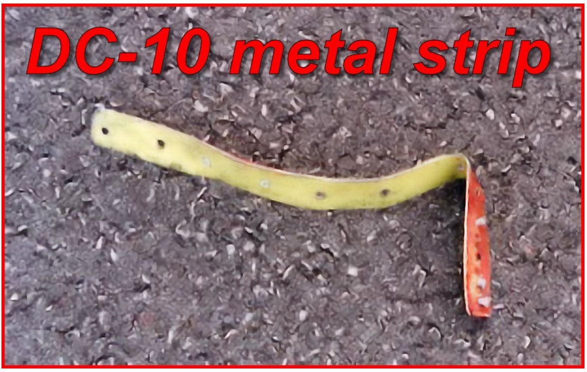
On 25 July 2000, Air France Flight 4590 crashed in Gonesse, France, after departing from Charles de Gaulle Airport en route to John F. Kennedy International Airport in New York City, killing all 100 passengers and nine crew members on board as well as four people on the ground. It was the only fatal accident involving Concorde. This crash also damaged Concorde's reputation and caused both British Airways and Air France to temporarily ground their fleets until modifications that involved strengthening the affected areas of the aircraft had been made.

According to the official investigation conducted by the Bureau of Enquiry and Analysis for Civil Aviation Safety (BEA), the crash was caused by a metallic strip that had fallen from a Continental Airlines DC-10 that had taken off minutes earlier. This fragment punctured a tyre on Concorde's left main wheel bogie during take-off. The tyre exploded, and a piece of rubber hit the fuel tank, which caused a fuel leak and led to a fire. The crew shut down engine number 2 in response to a fire warning, and with engine number 1 surging and producing little power, the aircraft was unable to gain altitude or speed. The aircraft entered a rapid pitch-up then a sudden descent, rolling left and crashing tail-low into the Hôtelissimo Les Relais Bleus Hotel in Gonesse.

The claim that a metallic strip caused the crash was disputed during the trial both by witnesses (including the pilot of then French President Jacques Chirac's aircraft that had just landed on an adjacent runway when Flight 4590 caught fire) and by an independent French TV investigation that found a wheel spacer had not been installed in the left-side main gear and that the plane caught fire some 1,000 feet from where the metallic strip lay. British investigators and former French Concorde pilots looked at several other possibilities that the BEA report ignored, including an unbalanced weight distribution in the fuel tanks and loose landing gear.

They came to the conclusion that the Concorde veered off course on the runway, which reduced takeoff speed below the crucial minimum. John Hutchinson, who had served as a Concorde captain for 15 years with British Airways, said "the fire on its own should have been 'eminently survivable; the pilot should have been able to fly his way out of trouble'", had it not been for a "lethal combination of operational error and 'negligence' by the maintenance department of Air France" that "nobody wants to talk about".

Air France flight 4590, July 25, 2000



The metal strip was from the thrust reverser cowl door of the number 3 engine of a Continental Airlines DC-10. This wear strip had been replaced at Tel Aviv, Israel, during a C check on 11 June 2000, and then again at Houston, Texas, on 9 July 2000.

On 6 December 2010, Continental Airlines and John Taylor, a mechanic who installed the metal strip, were found guilty of involuntary manslaughter; however, on 30 November 2012, a French court overturned the conviction, saying mistakes by Continental and Taylor did not make them criminally responsible.

The 2010 trial involving Continental Airlines over the crash of Flight 4590 established that from 1976 until Flight 4590 there had been 57 tyre failures involving Concordes during takeoffs, including a near-crash at Dulles Airport on 14 June 1979 involving Air France Flight 54 where a tyre blowout pierced the plane's fuel tank and damaged the port-side engine and electrical cables, with the loss of two of the craft's hydraulic systems.

(**Note**) The author, Larry W Jones, was a colleague of fellow Continental Airlines aircraft mechanic John Taylor at Houston when this occurred.

Continental Airlines mechanics Roger Fraser and Larry W Jones

Could not find a photo of John Taylor

Concorde breaking sound barrier

Concorde
On the Wings Of Time

What it was like to pilot the supersonic Concorde jet

On January 21, 1976 a teenage John Tye was among crowds of onlookers clinging to a chain link fence, cheering as the first commercial British Airways Concorde flight departed from London's Heathrow airport. Tye was exhilarated, amazed and inspired as he saw this sleek, supersonic airplane of the future climb into the skies and make history. Little did Tye know some 20 years later, he'd be sitting in the Concorde flight deck for the first time, pinching himself that his teenage dream was coming true.

Captain John Tye

John Tye vividly recalls his first moments flying Concorde. Sure, he'd gone through extensive training, he'd practiced on the simulator – but this was the real deal. It was a feeling he could never have fully prepared for. Tye and his fellow training pilots were in Seville, Spain. It was a beautiful Thursday evening – "the sun was just setting, you could see a big ball of fire at the end of runway," as Tye puts it. "We got in and started the engines, and to feel those four Rolls-Royce Olympus engines starting up and the airplane vibration for the very first time was just absolutely mind blowing," Tye synchronized his watch with the co-pilot and the flight engineer. Then, they counted down and prepared for takeoff. "It's 'three, two, one – now,' and I pushed all four throttles fully forward in my left hand and I was just shoved back into my seat – an experience I could never describe, the acceleration as you shot off down the runway," he says. Then, the Concorde was in the air, building height. "That 20 minutes was the most incredible experience in my aviation career. It was just absolutely unbelievable," says Tye.

If comparatively few people experienced what it was like to travel on Concorde, even fewer know the feeling of piloting the fastest passenger plane ever to enter commercial service. When Tye first piloted Concorde in the late 1990s, the airplane had been established for two decades. Peter Duffey was there at the very beginning, as one of the first British Airways pilots selected to trial the aircraft. "I was involved in the development – flying with the test pilots." "We flew to Australia and Canada, carrying a lot of passengers." Duffey learned to fly as a Royal Air Force pilot during World War II. He later flew the de Havilland Comet, the first turbo jet engine aircraft, and one of its successors, the de Havilland Comet 4. When Concorde came calling, Duffey was an established British Airways training pilot on the Boeing 707. "We knew Concorde was coming, and most people felt intrigued and wanted to get onto the aircraft. So I put my name down for it," he recalls. Duffey helped mastermind the first Concorde training scheme, and flew the aircraft until he retired in 1980.

Captain Peter Duffey

Also there at the beginning was pilot Jock Lowe, who shares a birthday with Concorde – he turned 25 the day Concorde first took to the skies in 1969. Lowe remembers watching the aircraft on television that day. “I thought to myself, ‘Yeah, that’s what I’ll do. I’ll go and fly Concorde – not really realizing what was involved,’” Lowe told CNN Travel.

Captain Jock Lowe

Like Duffey, Lowe was one of the first British Airways pilots to test out supersonic flying at RAF Barford St. John, a military airbase in central England. “It was quite a shock because I walked around the hangar on a foggy February morning at RAF Barford – and I’d never even seen the aeroplane for real before,” says Lowe.” An hour later, Lowe says he was “let loose” with the Concorde, and it felt “amazing.”

“We went up to about 63,000 feet and started to throw the aeroplane around,” he recalls. Lowe says the feeling, an analogy often echoed in Concorde circles, was “like going from a bus to a Formula One sports car.”

Lowe ended up on the first BA training course in 1976 and was still on the Concorde fleet when he retired in 2001, earning him the accolade of the longest-serving British Airways Concorde pilot.

“I flew it for longer than anyone else, by quite a margin. But, because I had lots of office jobs as well, I didn’t do as many hours as some of them,” says Lowe, who also served as BA’s flight operations director.

Captain Barbara Harmer

Barbara Harmer (14 September 1953 – 20 February 2011) was the first qualified female Concorde pilot. Harmer's first experience in the aviation industry was as an air traffic controller at London Gatwick Airport. She also began flying lessons, gained her Private Pilot Licence (PPL) and became an instructor at Goodwood Flying School. Harmer studied for two years to gain a Commercial Pilot Licence (CPL), which she obtained in May 1982. She then made over 100 applications before securing a job as pilot at Genair, a small commuter airline based at Humberside Airport.

In March 1984, Harmer joined British Caledonian and flew BAC One-Elevens for three years. She then started flying the long haul McDonnell Douglas DC-10. In 1987, British Caledonian merged with British Airways, the airline operating Concorde in the UK. At that time, British Airways employed over 3000 pilots, but only 60 of them were women and no woman had ever piloted Concorde. Harmer was chosen to undergo the intensive six-month conversion course for Concorde in 1992. On 25 March 1993 Harmer became the first qualified female Concorde pilot and later that year made her first Concorde flight as First Officer to New York City's John F. Kennedy International Airport (JFK). Jacqueline Auriol was the first woman to fly Concorde as a test pilot. By the time Concorde was withdrawn from service in October 2003, Harmer had served 10 years as a pilot flying regular scheduled services. In 2001, an Air France pilot, Béatrice Vialle, had become the second of only two women to fly Concorde on regular routes by making some 35 trips between Paris and New York before the service was withdrawn. After Concorde, Harmer converted to the Boeing 777 until taking voluntary redundancy in 2009. She died at St. Wilfrid's Hospice, Chichester, aged 57.

Concorde
On the Wings Of Time

End of the line

The Concorde story ended in November 2003, when the last commercial flight landed in a Bristol airfield. There were a number of factors leading to Concorde's retirement in 2003. In 2000, a fatal Air France Concorde accident led to an investigation and various modifications to the aircraft. Concorde was very reliant on these regular customers who crossed the Atlantic frequently for work. Captains Westray and Lowe say several Concorde frequent flyers worked in the World Trade Center and were killed on 9/11. These terrorist attacks also impacted global confidence in air travel more generally.

And by the early 21st century, Concorde was getting old, and there were significant costs involved in the aircraft's upkeep. "I wasn't surprised it was retired, they kept it going as long as possible," says Duffey. "But the maintenance costs were very large."

"It was going to have to go sometime," agrees Lowe. "I think it was a little premature, but it would have stopped when the banking crisis came along in 2008, because we'd have lost half our passengers." Tye says his Concorde career came to an end without him realizing. In August 2000, he was about to take off at Heathrow when he got a call telling him to return Concorde to the gate because BA was grounding the aircraft.

"What I didn't know then was I wouldn't ever get back on Concorde," says Tye. "Because of that, I didn't have any mementos. I didn't have any significant souvenirs, and I was planning to carry on flying Concorde for the rest of my career." While Concorde did return for a couple of years before its final goodbye, in the interim, Tye became a BA Airbus captain and never returned to supersonic flying. Concorde's final flight was, for Tye, a "a very, very sad, emotional day." "It was a very emotional period, a lot of tears were shed," echoes Westray, recalling an "emotional farewell" from air traffic control on his final Concorde flight from New York in 2003. When Concorde ended, Westray was grateful he was still young, and could train on another big aircraft and continue his aviation career. "It never lost its excitement. It was always exhilarating". Jock Lowe, former Concorde pilot.

END – Concorde – On The Wings Of Time

About the Author

Larry W Jones spent 41 years as an aircraft technician, avionics specialist and Airline Maintenance Control Supervisor before retiring in November 2008. He is a songwriter, having penned over 7,700 song lyrics. Published in 22 volumes of island themed, country, cowboy, western and bluegrass songs. The entire assemblage is the world's largest collection of lyrics written by an individual songwriter.

As a wrangler on the "Great American Horse Drive", at age 68, he assisted in driving 800 half-wild horses 62 miles in two days, from Winter pasture grounds in far NW Colorado to the Big Gulch Ranch outside of Craig Colorado.

His book, "The Oldest Greenhorn", chronicles the adventures and perils in earning the "Gate-to-Gate" trophy belt buckle the hard way.

Other books published by Larry W Jones:

1. A Squirrel Named Julie and The Fox Ridge Fox
2. The Painting Of A Dream
3. The Boy With Green Thumbs and The Wild Tree Man
4. Red Cloud – Chief Of the Sioux
5. Spotted Tail – The Orphan Negotiator
6. Little Crow – The Fur Trapper’s Patron
7. Chief Gall – The Strategist
8. Crazy Horse – The Vision Quest Warrior
9. Sitting Bull - The Powder River Power
10. Rain-In-The-Face – The Setting Sun Brave
11. Two Strike – The Lakota Club Fighter
12. Chief American Horse – The Oglala Councilor
13. Chief Dull Knife – The Sharp-Witted Cheyenne
14. Chief Joseph – Retreat From Grande Ronde
15. The Oregon Trail Orphans
16. Kids In Bloom Volume 1
17. Kids In Bloom Volume 2
18. Kids Animal Pals Volume 1
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34. The Jungle Book – The White Seal
35. The Jungle Book – Rikki-Tikki-Tavi
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54. China Clipper – Floatplanes Of Pan Am
55. Images Of Old England
56. Range Of A Cowboy
57. Clipper Ships – Emigrants Passage
58. Clipper Ships – Wool and Wealth
59. Clipper Ships – Iron Maidens
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135. Texas Rangers - The Outlaw Sam Bass
136. Texas Rangers - Fight With Apaches
137. Texas Rangers - Chief Victorio
138. Texas Rangers - Last Fight With Apaches
139. Texas Rangers - Last Scoutings

All his publications are available on Lulu.com